6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Long-term simulation of large deformation, mechano-chemical FSI in ALE and fully Eulerian coordinates

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Keywords: *fluid-structure interaction, solid growth, fully Eulerian approach, arbitrary Lagrangian-Eulerian approach, homogenization in time, temporal multi-scales*

In this presentation, we develop numerical schemes for mechano-chemical fluid-structure interactions with long-term effects [1]. We investigate a model of a growing solid interacting with an incompressible fluid. A typical example for such a situation is the formation and growth of plaque in blood vessels. This application includes two particular difficulties: First, growth may lead to very large deformations, up to full clogging of the fluid domain. We derive a simplified set of equations including a fluid-structure interaction system coupled to an ODE model for plaque growth in Arbitrary Lagrangian Eulerian (ALE) coordinates [2] and in Eulerian coordinates [3]. The latter novel technique is capable to compute very large deformations up to contact. The second difficulty stems from the different time scales: while the dynamics of the fluid demand to resolve a scale of seconds, growth typically takes place in a range of months. We propose a temporal two-scale approach using local small-scale problems to compute an effective wall stress that will enter the long-scale problem. Our proposed techniques are substantiated with several numerical tests that include fully Eulerian and ALE comparisons and convergence studies.

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